Diversity of the Fusion Crust of the Allende CV Chondrite

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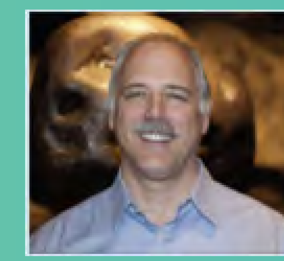

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Introduction

The fusion crust of meteorites forms due to the high speed interaction of the thin melt layer with air molecules when entering Earth's atmosphere [1]. There is limited information about the petrology and mineralogy of fusion crust of chondritic meteorites, as they have been described in a more general sense. These studies [e.g., 1, 2] have provided insights into the distinct features of the fusion crust on different types of meteorites, but more information is needed to fully grasp its formation and diversity in relation to underlying surface petrology. For this reason, the fusion crust of the Allende CV3 chondrite was analyzed with regards to its mineralogy and petrology. The results of this study were compared to previous work [e.g., 1], identifying differences and similarities in measurement and interpretation. Studying one single meteorite fall provides more details regarding the mineraology and petrology of fusion crust, what processes control its development, and how it can vary across a single surface.

Methodology

Sample Preparation

- o Picking and mounting fusion crust
- o Total of 20 pieces mounted

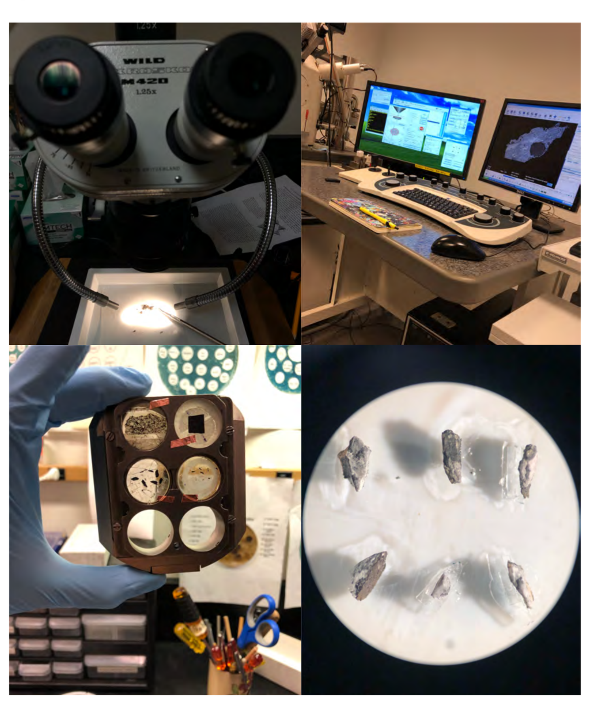

Fig. 1. Sample preparation and laboratory work done at AMNH.

Laboratory Work

- o CAMECA SX100 Electron Microprobe for element mapping
- o Zeiss EVO60 SEM for BSE images

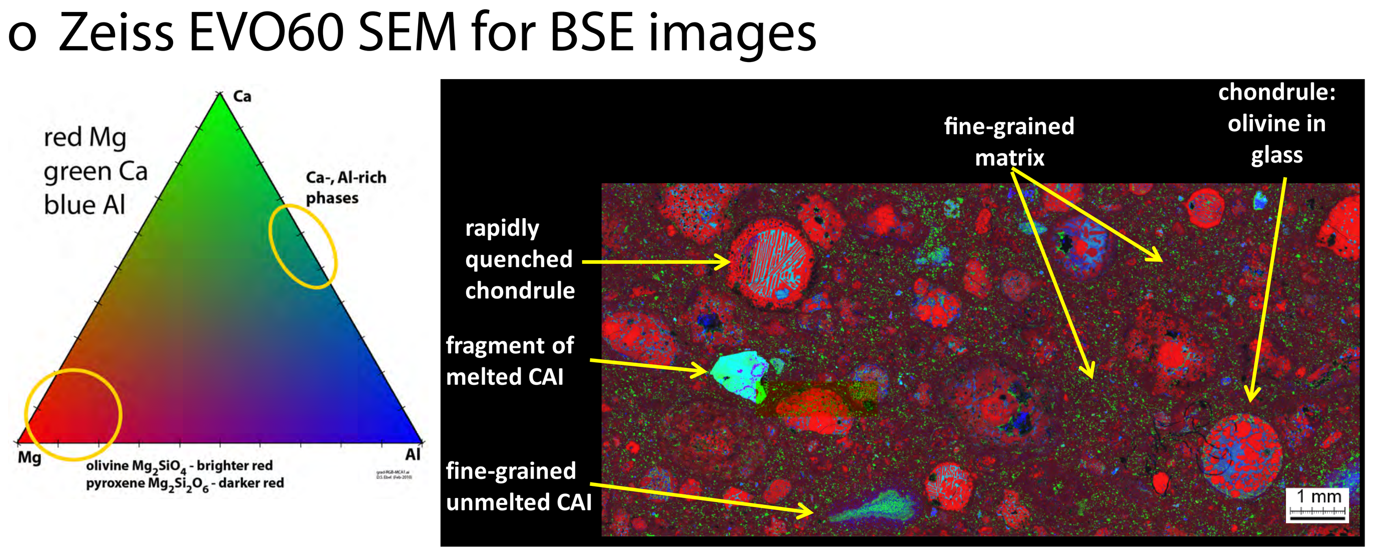

Fig. 2. Mg-Ca-Al example of red-green-blue (RGB) element composite map (Allende, CV3, AMNH 4948-t2-ps1A)

Results

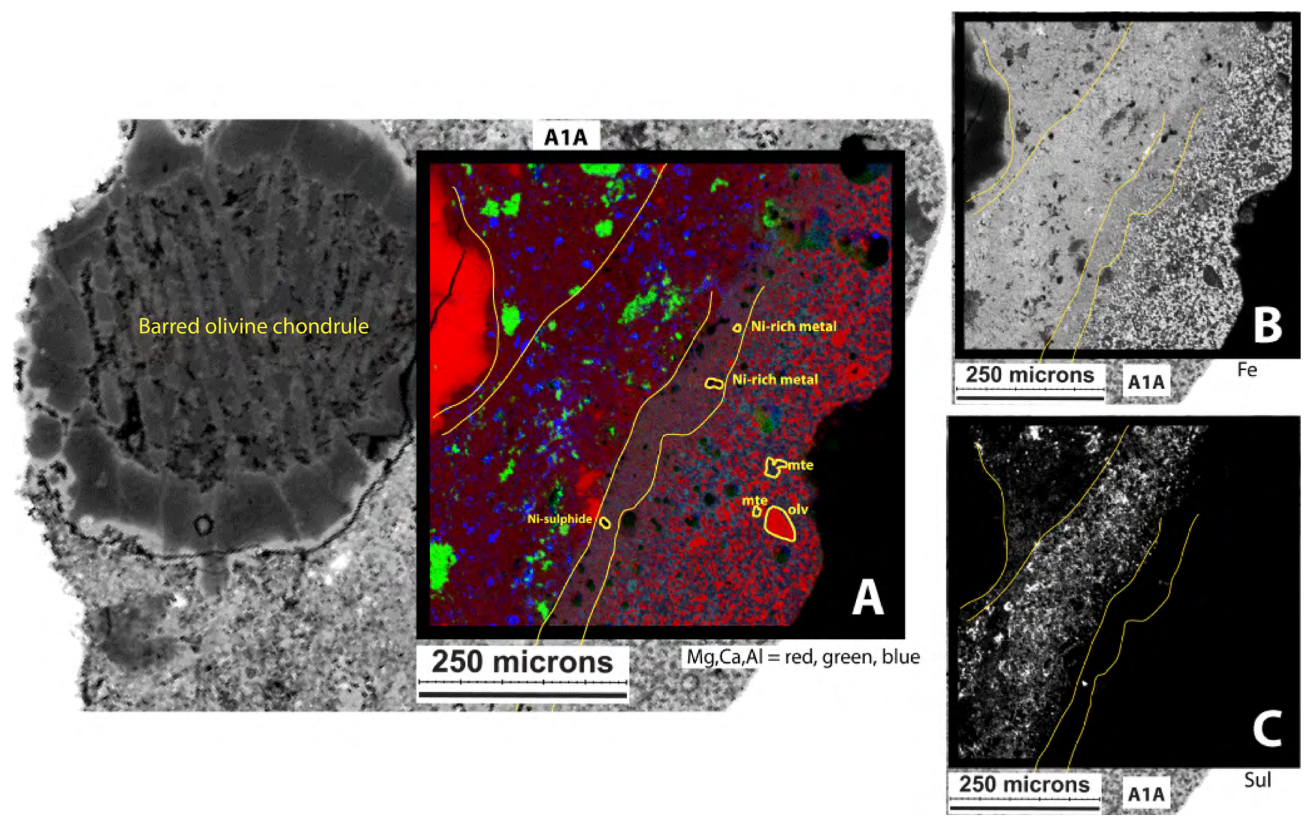

Fig. 3. A1A Fusion crust underlain by chondrule. (a) Mg, Ca, Al map overlay on BSE image. Minerals such as olivine (olv), magnetite (mte), Ni-sulfide, and Ni-metal are identified. Layers in the fusion crust are identified. (b) Fe map. Fe content is high in the fusion crust, becoming less abundant inwards the crust. (c) Sulfur map. The matrix is S-rich, but S abundance decreases approaching the Mg-rich olivine rim of the barred-olivine chondrule.

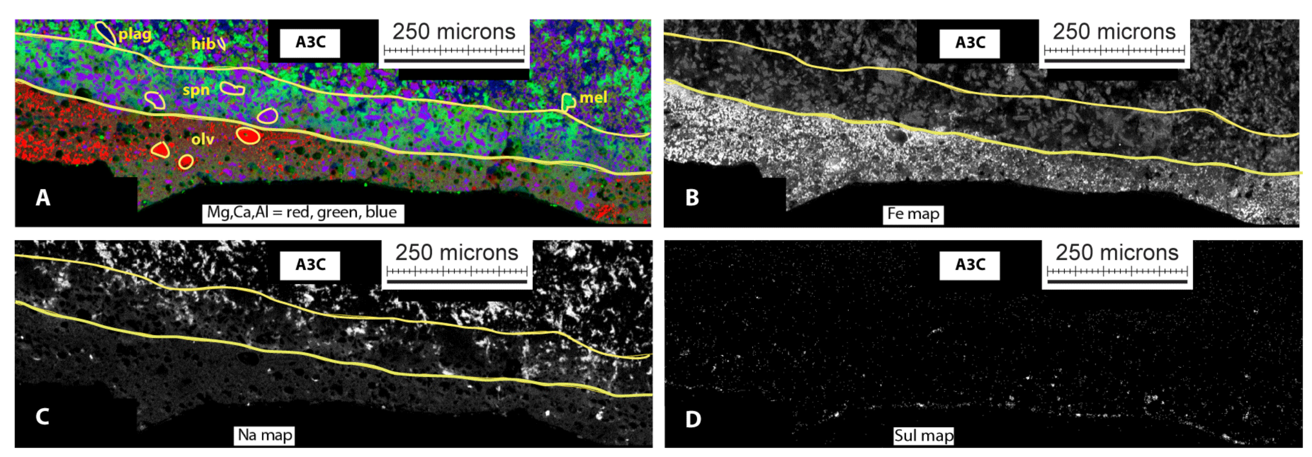

Fig. 4. A3C Fusion crust underlain by fine-grained CAI. (a) Mg, Ca, Al map. Layers are visible throughout the sample. Mg-rich olivine (olv, red), spinel (spn, purple), plagioclase (plag, dark blue), hibonite intergrowths in spinel (hib, blue), and melilite (mel, green) can be identified. (b) Fe map. The fusion crust is high in Fe, but it decreases moving inward. (c) Na map. The inner part of the sample is rich in Na; however, it becomes less abundant moving outwards, the fusion crust being depleted in Na. (d) Sul map. There is essentially no sulfur in the sample and no sulfide enriched layer in the matrix. There are very low amounts of Sul in the fusion crust, with the rest being background noise.

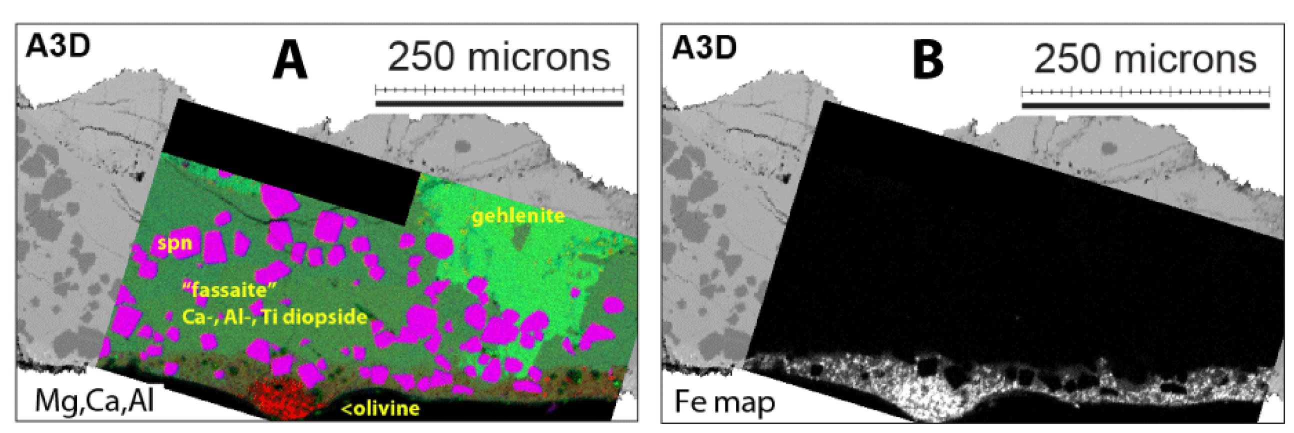

Fig. 5. A3D Fusion crust underlain by igneous (Type B) CAI. (a) Mg, Ca, Al map. The fusion crust can be distinguished from the underlying material, but there is no layering. The mineral composition of this sample include spinel (spn, purple), fassaitic pyroxene (dark green), and gehlenite (light green) in the CAI portion and olivine (red) in the fusion crust. (b) Fe map. In this sample, Fe is only found in the fusion crust. The rest of the sample is completely Fe-free, contrary to what was seen previously.

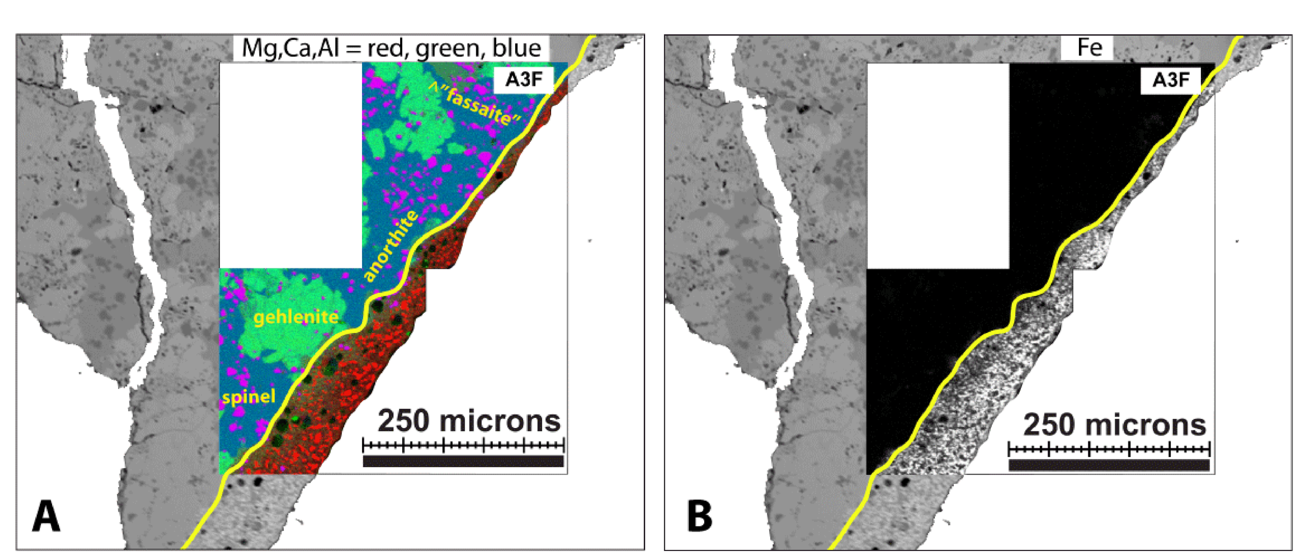

Fig. 6. A3F Fusion crust underlain by igneous CAI. (a) Mg, Ca, Al map. The CAI and fusion crust are distinguishable from one another, but no layers are seen in the fusion crust. Spinel (purple), gehlenite (light green), fassaitic pyroxene (dark green), and anorthite (blue) are the main components of the CAI. (b) Fe map. Note that the fusion crust is rich in Fe, but there is no Fe in the underlying CAI material.

Conclusion

The study of fusion crust of the Allende CV chondrite has given insight into its mineralogical and petrological features. Our results indicate that previous descriptions match what was identified in the fusion crust of areas underlain by chondrules and matrix, but significantly differ from areas underlain by CAIs. With new insights on the behavior of fusion crust with CAI substrate, we have concluded that the structure of the fusion crust is influenced by the underlying material, and that lateral flow of the melted crust must also play a key role in the composition of the fusion crust in different areas.

Discussion

Fusion crust has been previously described [1, 2] as heterogeneous, with an inner layer and outer or melted crust (MC). In CV chondrites (Fig. 7), the MC layer is underlain by an outer substrate (OS) containing sulfide and metal droplets, as well as an inner substrate (IS) with sulfide and metal veins [1]. The matrix below the MC lacks the OS but contains a sulfide-enriched substrate (SS). A1A (Fig. 3) accords with the previous description for CV crust [1], where the SS, OS, and IS below the MC can be identified.

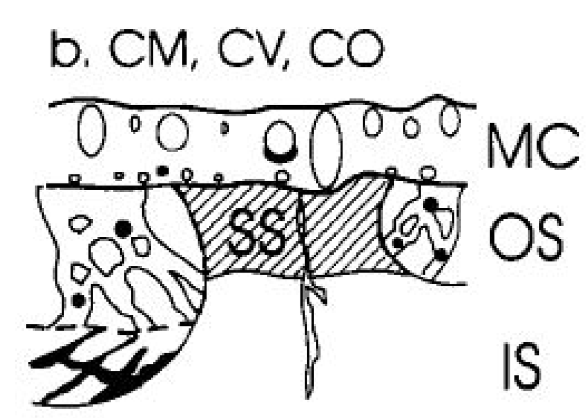

Fig. 7. Representation of the fusion crust structure for CV chondrites [1]. Above condrules, the melted crust (MC) is underlain by an outer substrate (OS) and an inner substrate (IS). Metal and sulfide droplets can be found in the OS, and the IS contains sulfide and metal veins. Above matrix there is a sulfide enriched substrate (SS) below the MC.

While there are layers in AC3 (Fig. 4), these strongly differ from that identified as typical for CV crust [1], with no sulfide droplets in the MC layer and no SS layer in the matrix. Based on its texture, we described A3C as a "fluffy" CAI, whereas both A3D (Fig. 5) and A3F (Fig. 6) appear to be melted, igneous "Type B" CAIs, with no layers identified. Spinel is common in all three samples, but A3C (Fig. 4) contains more Na-rich minerals. Na is only found in the inner portion; its lack in outer portions and the fusion crust can be attributed to its volatility relative to Ca, Al, Si, and Mg. A3D (Fig. 5) and A3F (Fig. 6) contain Ca-rich minerals such as gehlenite and anorthite. Fe¬ is found in the fusion crust of the three samples, but much lower amounts of Fe are found in the underlying material of A3C (Fig. 4), specifically in spinel crystals, probably due to mild aqueous alteration on the parent body. Fe in A3D (Fig, 5) and A3F (Fig. 6) is only found in the fusion crust. Since there is no Fe in the underlying material of these two samples, Fe must have been derived from lateral migration or flow. When the outer part of a meteorite is melting before forming the fusion crust, our results demonstrate movement of the material from different directions, explaining why there is Fe in the fusion crust of samples with no Fe in the underlying material.

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References:

[1] Genge M. J. and Grady M. M. (1999) Meteoritics and Planetary Science, 34, 341– 356.
[2] Genge M. J. and Grady M. M. (1999) Mineralogical Magazine, 63, 473-488.